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ORBIT SELECTION CRITERIA FOR OPTICAL DUAL-USE EARTH OBSERVATION SATELLITES

Abstract

Dual-use space missions, putting together different classes of users and needs, are designed to fulfill multiple objectives; typical applications are related to surveillance, intelligence, crisis management tasks, as far as the Defence domain is concerned, and risk prevention, monitor, and management for Institutional civilian users, and related potential commercial affairs. The goal of this paper is to present a methodology to identify criteria for selecting the key parameters to characterize the orbits that best fit the abovementioned dual mission scenario. For each of the applications areas, the main top level requirements and constraints that affect the orbit selection process are identified. Global accessibility, with greater focus on coverage of areas of primary interest – located in the Northern or the Southern hemisphere, very-high/high imaging quality and short revisit time are the top level requirements common to both military and civilian applications. The primary constraints to be taken into account are primarily related to the utilization of optical payload, therefore imaging acquisition conditions in terms of allowed solar zenith angle values and cloud coverage minimization. Analyzing the mission scenario characteristics, a first wide range of orbital altitude is initially derived. From a qualitative top-level orbital trade-off, in which advantages and drawbacks of different orbit families are compared, Sun-synchronous orbits are selected as the best option, guaranteeing high latitude accessibility, and nearly constant illumination conditions over target areas. The local time of passage to the node is the second key parameter to be assessed in order to maximize observation opportunities throughout the whole year taking into account suitable on-ground illumination conditions, and cloud coverage probability. Once detected initial allowed ranges, a parametric analysis on the orbital altitude and maximum off-nadir look angle was performed to evaluate how their variation affects the identified coverage and spatial resolution figure of merits (and mission lifetime just for the altitude variation). Further parametric analysis were performed firstly on LTAN/LTDN values and successively introducing variable solar zenith angle acquisition constraints, evaluating as main output data coverage performance and mission lifetime; cloud coverage statistical modeling was also explored to contribute in the detection of the most fitting node values. The illustrated methodology allows to solve orbital trade–offs, by identifying and characterizing the most fitting orbit for a dual-use mission scenario by optical instruments. Parametric simulations were performed by using the software product SatelliteToolKit (STK), taking full benefit from the features of its additional modules STK/Coverage and STK/Analyzer.